Offre de Stage IPSL 2024

(Soutenu par le programme EUR IPSL-*Climate Graduate School)*

Titre du sujet de stage : **USING MACHINE LEARNING TO DERIVE EFFECTIVE EQUATIONS TURBULENT AND GEOPHYSICAL FLOWS**

Description du sujet (1 page maximum) :

Turbulent and geophysical flows are multi-component, and imply a pharaonic range of scales: for example, the atmosphere cover span all scales between that of hurricanes (100 km) and those at which energy is dissipated (0.1 mm), corresponding to a range of scales of 10^{11}. This range of scale is inaccessible to the largest computers currently in existence, which have neither enough memory nor enough CPU to handle such a large number of degrees of freedom.

Moreover, the complete treatment of all scales of the problem hides an enormous waste: 90 percent of computer resources are monopolized by the treatment of very small scales (less than 1m), while only large scales are of interest to scientists, the climate at the scale of a house having little relevance.

A solution is to introduce "turbulence models", whereby the influence of small scales is parameterized via empirical laws, at the cost of introducing adjustable parameters. Nowadays, the most popular approach is to use a Large Eddy simulation strategy, in which only the large scales are simulated: present climate models have a grid size of 10 km, allowing to handle the data volume in 2 CPU seconds per time step. However, there is no free lunch: the price to pay for such a mode reduction is the addition of a (sometime very large) damping, to avoid accumulation of energy at the smallest simulated scale. In LES type climate simulations, the damping is the same as if the atmosphere were made of peanut butter and ocean of honey, so that no fluctuations can develop. This is problematic to capture possible bifurcations.

In this internship, we propose a new approach, based on deriving “effective equations of motions” from turbulent or geophysical data using a combination of theory and machine learning tool. The idea is to postulate a priori which type of partial differential are relevent using symmetry argument and asymptotic theory [1], and then fit the correspnding coefficient using a deep neural network. Such a kind of approach has already been used in SPEC group for modelling active matters [2].

Bibliography ;

[1] Ruppert Klein, Scale-Dependent Models for Atmospheric Flows, **Annual Review of Fluid Mechanics**,Vol.42:249-274(2010)
https://doi.org/10.1146/annurev-fluid-121108-145537

[2] R. Granier, PhD thesis under the supervision of Hugues Chaté.

Résumé en anglais (5 lignes) :
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Niveau du stage (Licence, M1, M2, *internship*) :
M2, Internship Ecole Centrale

Licence ou Master(s) où sera proposé le sujet : Central Supelec, M2 ECLAT Paris Saclay, M2 Geosciences ENS Paris

Thème scientifique de l'IPSL concerné : SAMA
Durée du stage : ___6_ mois

Période : 15/06/2024-15/12/2024

Rémunération de l'ordre de 580 euros par mois.

Est-il prévu une thèse dans le prolongement du stage ? oui